Student-Led Active Learning Workshops: Increasing Student Retention, Decreasing Time to Graduation and Providing High-Performing Students with Opportunities to Develop Coaching Skills

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Abstract

Many engineering students come to upper-division courses with inadequate problem solving skills. As a result, they often repeat core courses, thus increasing their time to graduation. One approach that had been tried in the past was to review material in class and offer retake exams. This approach proved both inefficient and ineffective, as student performance on retake exams was often as poor as it was on the original test. In Fall 2011 a new approach was introduced. Students are now required to attend a workshop before retaking a test. Officers of the student chapter of the aerospace engineering honor society lead the workshops. These highly performing students have a good grasp of the material and are trained to conduct the workshops using active learning strategies. The workshops have resulted in significant improvement of student test scores, while at the same time providing opportunities for student leaders to sharpen their coaching skills.

Keywords: Retention, Decreasing Time-to-Graduation, Problem Solving Skills, Course Design

1. Introduction

Engineers are by definition problem solvers. Hence, it is only natural that a great portion of most engineering courses is dedicated to teaching discipline-specific problem solving skills. Textbook problems usually involve straightforward applications of mathematics and science in well-defined situations, in which there is usually a single correct answer. These types of problems are much simpler than the real world problems professional engineers are called to solve, however, they play an important role in bridging the gap between theory and application. It is these fairly simple, straightforward problems that help students develop the foundational skills on which they can build real world open-ended problem solving skills and design skills.

Nevertheless, it is well documented by several studies (see, for example, (2), (5), (6)) that engineering graduates do not possess adequate problem solving skills. This is a problem that persists not only in the U.S. but also around the world (6). In one of these studies students showed no improvement in problem solving skills even though they observed at least 1,000 examples worked on the board and solved more than 3,000 problems in homework by the time they completed their undergraduate work (5). Obviously, something is not working.

In a previous study Mourtos (3) documented the various challenges students face in solving open-ended problems. In the cognitive domain, the top difficulties identified were the ability to (a) apply first principles in the solution of problems, (b) reflect on the problem solving process, (c) self-assess their own problem solving skills, and (d) select a valid physical and mathematical model for a given problem. More disturbingly, students also exhibit affective difficulties, such as unwillingness to spend sufficient time on task, reluctance to write down ideas and sketch while solving a problem, and inability to deal with ambiguity.

This study highlights the fact that students face these difficulties not only when they attempt to tackle open-ended problems, which may be understandable due to the very nature of these problems, but also when they attempt to solve fairly simple, straightforward textbook problems. As a result, many students perform poorly on tests and end up repeating core courses, thus increasing their time to graduation. In Fall 2010, for example, in Aerodynamics I (AE160), 37% of the students received non-passing grades. Of these, some dropped out of the BSAE program, some went on probation, and the rest returned in Fall 2011 to repeat the course. The following sub-sections discuss the factors, which are thought to be the main contributors for this lack of basic engineering problem solving skills.

1.1 Inadequate Skills in Mathematics and Physics

Students consistently enter engineering programs with inadequate skills in mathematics and science. Approximately one third of incoming freshmen at SJSU must take remedial math. Although this percentage is probably smaller among engineering freshmen, students who begin their studies with pre-calculus and analytic geometry, naturally increase their time to graduation. Similarly, fewer than 5% of the incoming freshmen pass the physics placement test. Consequently, most students take a four-semester course sequence (14 units) in physics instead of the three-semester sequence (12 units) designed for engineering freshmen with adequate high-school physics. Although juniors who take upper division courses have passed at least their first physics course (mechanics) and the entire calculus series, they still struggle when it comes to applying mathematics and physics while solving engineering problems.

In an effort to determine as accurately as possibly the real weaknesses in students' problem solving skills, student exams were analysed in the courses described in Section 2, especially in topics in which students seemed to earn the lowest scores. The following patterns emerged as key contributors, when students failed to complete the solution of a problem:

a. Inability to integrate simple functions.
b. Inability to determine the constants in an equation for a straight line.
c. Inadequate understanding of functions; e.g. cannot distinguish between the radius of a circle R (a known constant in some problems) and the polar coordinate r (a variable).
d. Inability to convert coordinates from one system to another.
e. Inability to draw free-body diagrams on a body or a control volume.
f. Inability to properly combine vectors.

Since students have earned passing grades in calculus and physics before allowed into engineering courses, we speculate that they simply do not posses working knowledge of the material. In other words, they may have been able to perform similar "out-of-context" exercises while taking math and physics, yet are unable to transfer their knowledge within an engineering context.

1.2 Students are not Coached in Problem Solving Skills

In most engineering classes, the emphasis tends to be on theory rather than on problem solving. Theory is, of course, absolutely essential. However, an understanding of theory alone is not sufficient. Demonstration is a necessary condition of learning (4), hence the next step involves observing how theory is applied to solve problems, from simple to more complex. Most engineering courses do a fair job in presenting an adequate number of such demonstrations and modern engineering textbooks include a large variety of examples to help students make the connection between theory and application.

Still, it is not possible to develop expertise in problem solving simply by understanding the theory and the examples presented in class or in the textbook. To develop any skill, it requires also proper coaching. Coaching involves more than presenting solutions. It involves having an expert observing the learner and providing real-time feedback on his/her problem solving. This is also known as "approximation", another established condition of learning (4). Unfortunately, common faculty teaching styles (e.g. pure lecturing) do not allow for student "approximation" and coaching during class. While faculty office hours offer opportunities for one-on-one or small group coaching outside of class, very few students take the time to seek coaching during office hours.

1.3 Inadequate Time-on-Task

Emerging empirical evidence shows that college students' academic effort has dramatically declined in recent decades. For example, full-time college students through the early 1960s spent roughly 40 hours per week on academic pursuits (i.e., combined studying and class time), while today the corresponding number is barely 27 hours per week. Average time studying per week fell from 25 hours in 1961 to 20 hours in 1981 and 13 hours in 2003 (1). The situation is probably worse at schools like SJSU, where students on average spend less time on campus and carry work and family responsibilities. Inadequate time-on-task may be part of a much larger problem, namely that many students come to college not only poorly prepared for highly demanding academic tasks but — more troubling still — also bring with them attitudes, norms, values, and behaviors that are often at odds with academic commitment (1).

1.4 Students' Lack of Individual Practice in Problem Solving

It is well known that no skill can be developed without practice. Grappling with concepts and problems is an essential part of the learning process. Yet students do not take the time to grapple with ideas and work through problems on their own. After a short, unsuccessful engagement with a problem, they seek help from the professor, the teaching assistant or a peer. When such help is not available, they look for solutions from which they attempt to cut and paste parts onto the problem at hand. This practice has become more and more prevalent as solutions to textbook problems have become widely available on the internet.

All of these factors, and possibly others not mentioned here, have created a culture, which is not conducive to developing engineering problem solving skills.

2. COURSE DESCRIPTION AND PEDAGOGY USED IN THIS STUDY

The following paragraphs describe briefly the courses used in this study.

- ME111–Fluid Mechanics: A junior-level course for mechanical, civil, and environmental engineers, with Calculus III (Math32) and Statics (CE95) as prerequisites. Sixty per cent (60%) of the course grade is based on exams, 20% on a team-based service-learning project, and 20% on team-based, open-ended problems.
- AE160–Aerodynamics I: The first aerospace engineering course in the BSAE curriculum. The prerequisites are Calculus III (Math32), Physics I–Mechanics (Phys50), and Engineering Reports (Engr100W). Sixty per cent (60%) of the grade is based on exams, 20% on team-based lab reports, and 20% on a team-based, service-learning project.
- AE162–Aerodynamics II: The prerequisites are AE160 and Engineering Reports (Engr100W). Sixty per cent (60%) of the grade is based on exams, 20% on team-based lab reports, and 20% on a team-based, integrated course project, which is shared with the Flight Mechanics course (AE165).
- AE164–Compressible Flow: The prerequisites are AE160 and Thermodynamics (ME113). Sixty per cent (60%) of the grade is based on exams, 20% on homework problems, and 20% on a team-based, integrated course project, which is shared with the Aerospace Propulsion course (AE167).

A few mechanical engineering majors take AE162 and/or AE164 as electives and they substitute ME111 as a prerequisite in lieu of AE160.

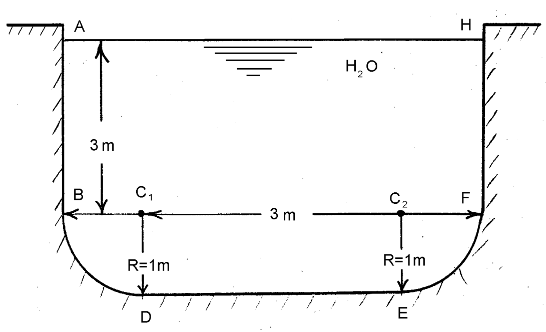
The first author taught all of these courses, collected and analysed the student performance data before and after implementation of the workshops. In all courses, before and after implementation of the workshops, students were coached in problem solving during class, using extensive active and cooperative learning techniques. In each topic at least three example problems were presented, each followed by a workout problem solved in small groups. During these workouts, the author answered questions and provided group guidance as necessary. Approximately half the teams in each class completed the workout problems correctly during the allotted class time; the other half completed the problems on their own outside of class and turned them in at a later time. These workout problems are graded and returned to the students. If students have difficulties with a particular problem, a student from a team, which has successfully solved the problem, is invited to present the solution to the rest of the class, while the instructor highlights the critical points.

3. WHY "REVIEW AND RETAKE" DOESN'T WORK

Students' inadequate preparation in mathematics and physics as well as their lack of problem solving skills first became apparent in the 1990's. One approach that was tried repeatedly in the past was to review test material in class, present additional example problems, and offer a retake exam. This approach proved both inefficient and ineffective, as students somehow expected that in-class reviews would replace individual study time, and retake exam problems would be similar to the problems discussed in class. Although review of exam problems in class after a test is taken is always a good practice, the additional review of material already taught, the presentation of additional example problems, and finally the makeup test itself, all took precious class time, which compromised the course content. Worse yet, student performance on retake exams was just as poor as it was on the original test. Only a very small percentage of students, typically around 5%, improved their performance and benefited from retake exams. It became apparent after many years that "review and retake" did not solve the problem of poor test performance because it did not address the root causes of the problem, namely insufficient time-on-task, lack of individual problem solving practice, and students' need for additional coaching. Hence, the approach of "review and retake" was discontinued.

4. A NEW APPROACH: STUDENT-LED PROBLEM SOLVING WORKSHOPS

In Fall 2011 a new approach was introduced to help improve student problem solving skills. Following a poor performance on a test, students are now required to attend a 90-minute workshop, during which they are expected to solve at least one problem. Attendance to the workshop and successful completion of a given problem is their ticket to the retake exam. The key idea of the workshops is to provide an opportunity for individual problem solving practice, while expert coaching is available. Unlike in-class workout problems, in which students work in teams, students are required to work alone during workshops, however, when they face difficulties they get immediate help from a workshop leader. If a workshop participant has difficulty getting started or completing a particular part of a problem, the student leader provides hints or even an outline of the entire solution, depending on the difficulty of the problem. Each workshop is offered at two different times, to accommodate as many students as possible. The ratio of leader-to-participant during the workshops varied from a low of 1:5 to a high of 1:15 in academic year 2011-2012, while the actual class size varied from 19 to 43 students. A sample workshop problem (solved) from ME111 (Fluid Mechanics) is shown below.



Determine the magnitude, line of action, and direction of the hydrostatic forces on the open conduit sections AB, BD, DE, EF, HF. The length of the conduit is 1 km.

Solution:

Starting with the horizontal bottom surface (DE), we observe that the hydrostatic force is equal to the weight of the water directly above the surface:

$F_{DE} = W_{H_2O-above} = \gamma(depth)(DE)L = 9{,}810\,(4)(3)1{,}000 \Rightarrow F_{DE} = 117.72\,MN$

The line of action of this force passes vertically through the center line of the conduit.

Continuing with the vertical sides: $F_{AB} = p_{1.5}A_{AB} = \gamma(1.5)(3x1{,}000) \Rightarrow F_{AB} = 44.145\,MN = F_{HF}$

The line of action of these forces passes horizontally (i.e., perpendicularly to each surface) at a depth of $(2/3)(AB) = 2\,m$.

Lastly, we calculate the hydrostatic force components on the circular arcs (BD) and (EF):

Horizontal: $F_{BD-h} = p_{3.5}A_{C_1D} = \gamma(3.5)(1x1{,}000) \Rightarrow F_{BD-h} = 34.34\ \ MN = F_{EF-h}$

Vertical: $F_{BD-v} = W_{H_2O-above} = \gamma\left(\forall_{BDC_1} + \forall_{ABC_1G}\right) = 9{,}810\left(\frac{\pi 1^2}{4} + 3x1\right) \Rightarrow F_{BD-v} = 37.14\,MN = F_{EF-v}$

The magnitude of the total hydrostatic force on each of the two arcs is:

$F_{tot} = \sqrt{F_h^2 + F_v^2} = \sqrt{34.34^2 + 37.14^2} \Rightarrow F_{tot} = 50.58\,MN$

The distributed pressure forces on each arc act normal to the surface. Thus, their line of action passes through the center of the arc. Since the resultant hydrostatic force is the integral of these pressure forces, its line of action also passes through the center of the each arc (C_1 for BD and C_2 for EF). The direction of these forces can be defined by the angle φ they make with the horizontal:

$\phi = \arctan\left(F_{BD-v} / F_{BD-h}\right) \Rightarrow \phi = 47.24^0$ *below the horizon.*

Officers of the student chapter of the aerospace engineering honor society (Sigma Gamma Tau) lead the workshops. These highly performing students have a good grasp of the course material and have successfully demonstrated problem solving skills in their coursework. Students are invited to join Sigma Gamma Tau based on their grade point average (must have B or better) and class standing (must be in the top 10% of their class). Following this invitation, perspective members have one year to earn their membership through service projects. Leading workshops and providing tutoring to their peers are two kinds of service that has been deemed acceptable. Student leaders are trained by the faculty to conduct the workshops using active learning strategies.

It should be noted that SJSU has been offering student-led, active learning workshops in mathematics and physics since Fall 2008. Unlike the Sigma Gamma Tau officers, the undergraduate peer-mentors who lead the math and physics workshops are paid through an NSF grant, which has provided funding for a Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) at SJSU. The data in Table 1 clearly show a marked improvement in student passing rates in calculus courses as a result of these workshops.

Table 1 – Passing rates (C- or better) in math courses taken by engineering students

		Fall 2008	Spring 2009	Fall 2009	Spring 2010	Fall 2010	Spring 2011	Fall 2011
Math 19 – Pre-calculus		77%	62%	78%	79%	77%	64%	77%
Math 30 – Calculus I			80%	80%	65%	80%	68%	89%
Math 30P – Calculus I + Pre-Calculus			67%	83%	70%	76%	76%	75%
Math 31 – Calculus II				63%	71%	68%	72%	83%
Overall w/o Workshops	50%							

Students are required to register for the workshops but may opt out by personally appealing to the Department Chair. However, those who do usually do not perform very well. For example, of students who opted out of the workshops in Physics 50 (Mechanics) in Fall 2011, only 50% received passing grades. These workshops provided the inspiration for implementing this idea in engineering courses.

5. ASSESSING THE EFFECTIVENESS OF THE WORKSHOPS

5.1 Comparing Student Performance in Tests with and without Workshops

Tables 2a, 3a, 4a, and 5a present data from earlier course offerings, without workshops. Tables 2b, 3b, 4b, and 5b present data from the latest offerings of the same courses in academic year 2011-2012, all of which included workshops. Almost all workshops were offered following poor test results, as a way to help students do better on the makeup tests. Thus, the main motivation for students to attend a workshop was the desire to improve their scores, so they could pass the course. The only exceptions were quiz 3 in AE162 (Table 3b) as well as quiz 5 and the final in ME111 (Table 5b). Students specifically asked for workshops before these tests, perhaps because they experienced difficulty with the topics, not to mention that they had also began to realize the benefits of the workshops.

In the earlier course offerings the exams included a combination of quizzes and midterms, along with a final exam. In the latest offerings midterms were replaced by a greater number of quizzes, with the intent to test students more frequently and focus each test on a single topic. The final exam is comprehensive, however, the emphasis is usually on topics presented in the latter half of the course.

Table 2a – Student performance in AE160 w/o workshops (Fall 2010, N=24)

Test & Topic	Number (%) of students who scored 70% or higher
Quiz 1 – Viscosity	3 (13%)
Quiz 2 – Aerodynamics Forces	2 (8 %)
Midterm – Viscosity & Aerodynamic Forces	14 (58%)
Quiz 3 – Continuity	4 (17%)
Quiz 4 – Momentum	3 (13%)
Final Exam	6 (25%)
All Exams	4 (17%)

Table 2b – Student performance in AE160 with workshops (Fall 2011, N=39)

	Number (%) of students who scored 70% or higher		
Test & Topic	Pre-Workshop	Post-Workshop	Total
Quiz 1 – Viscosity	16 (41%)	+16 (+41%)	32 (82%)
Quiz 2 – Aerodynamics Forces	7 (18%)	+13 (33%)	20 (51%)
Quiz 3 – Flow Similarity	24 (62%)	+10 (26%)	34 (87%)
Quiz 4 – Continuity	22 (56%)	+10 (26%)	32 (82%)
Quiz 5 – Momentum	6 (15%)	+16 (41%)	22 (56%)
Final Exam	5 (13%)		5 (13%)
All Exams	22 (56%)		

Table 3a – Student performance in AE162 w/o workshops (Spring 2011, N=23)

Test & Topic	Number (%) of students who scored 70% or higher
Quiz 1 – Potential Flow Theory	6 (26%)
Midterm 1 – Potential Flow Theory	9 (39 %)
Quiz 2 – Airfoil Theory	16 (70%)
Midterm 2 – Airfoil &Wing Theory, Aerodynamic Interference	20 (87%)
Final Exam	15 (65%)
All Exams	11 (48%)

Table 3b – Student performance in AE162 with workshops (Spring 2012, N=43)

	Number (%) of students who scored 70% or higher		
Test & Topic	Pre-Workshop	Post-Workshop	Total
Quiz 1 - Potential Flow Theory	9 (21%)	+13 (30%)	21 (49%)
Quiz 2 – Airfoil Theory	6 (14%)	+35 (81%)	41 (95%)
Quiz 3 – Wings, Aerodynamic Interference			7 (16%)
All Exams	16 (37%)		

Table 4a – Student performance in AE164 w/o workshops (Fall 2010, N=15)

Test & Topic	Number (%) of students who scored 70% or higher
Quiz 1 – Isentropic Flow	1 (7%)
Quiz 2 – Isentropic Flow, Normal Shocks	5 (33%)
Midterm 1 – Isentropic Flow, Normal Shocks, Flow with Heat Addition, Flow with Friction	11 (73%)
Quiz 3 – Oblique Shocks, Expansion Waves	7 (47%)
Quiz 5 – Quasi-One-Dimensional Flow	8 (53%)
Final Exam	15 (100%)
All Exams	7 (47%)

Table 4b – Student performance in AE164 with workshops (Fall 2011, N=19)

	Number (%) of students who scored 70% or higher		
Test & Topic	Pre-Workshop	Post-Workshop	Total
Quiz 1 – Isentropic Flow	6 (32%)	+7 (37%)	13 (68%)
Quiz 2 – Normal Shocks	10 (53%)	+8 (42%)	18 (95%)
Quiz 3 – Flow with Heat Addition	16 (84%)	+2 (22%)	18 (95%)
Quiz 4 – Flow with Friction	14 (74%)	+4 (21%)	18 (95%)
Quiz 5 – Oblique Shocks, Expansion Waves	5 (26%)	+3 (16%)	8 (42%)
Quiz 6 – Quasi 1-D Flow	10 (53%)	+3 (16%)	13 (68%)
Final Exam	+3 (16%)		+3 (16%)
All Exams	11 (58%)		

Table 5a – Student performance in ME111 w/o workshops (Fall 2009, N=39)

Test & Topic	Number (%) of students who scored 70% or higher
Midterm 1 – Fluid Properties, Fluid Statics, Continuity	27 (69%)
Midterm 2 – Continuity, Bernoulli, Momentum, Energy	14 (36%)
Final Exam	12 (31%)
All Exams	14 (36%)

Table 5b – Student performance in ME111 with workshops (Spring 2012, N=35)

	Number (%) of students who scored 70% or higher

Test & Topic	Pre-Workshop	Post-Workshop	Total
Quiz 1 – Fluid Properties	6 (17%)	+10 (29%)	16 (46%)
Quiz 2 – Fluid Statics	18 (51%)	+0 (0%)	18 (51%)
Quiz 3 – Continuity	24 (69%)	+7 (20%)	31 (89%)
Quiz 4 – Bernoulli	3 (9%)	+7 (20%)	10 (29%)
Quiz 5 – Momentum			21 (60%)
Final Exam			16 (46%)
All Exams	18 (51%)		

The data in tables 2a, 3a, 4a, and 5a as well as those in the pre-workshop columns in tables 2b, 3b, 4b, and 5b, clearly show that students in general perform poorly on tests. Obviously using proper pedagogy in class, as described in Section 2, is not sufficient to ensure development of problem solving skills when students do not spend adequate time practicing on their own. Nevertheless, tables 2b, 3b, 4b, and 5b show that student performance improved significantly after implementing the workshops. It should be noted that many more students achieve higher scores on the makeup tests following the workshops but their improvements are not included in the statistics shown. For example, when a student scores 70% on the pre-workshop test and subsequently scores 90% on the makeup test, his/her improvement is not reflected in the class statistics since he/she met the 70% target on the first test, without the workshop. Similarly, if a student scores 30% on the pre-workshop test and 60% on the makeup, his/her improvement is not reflected in the class statistics since he/she did not meet the 70% target.

5.2 The Students' Perspective

Student input regarding the workshops was solicited in Spring 2012 through a survey with three questions:

(a) Have the workshops been helpful to you personally?
(b) If your answer to question (a) is "yes", in what specific ways have the workshops improved your understanding of the material and your skills?
(c) In what ways could we improve the workshops in the future?

Table 6 summarizes some of the student input.

Table 6 – Summary of student input regarding the workshops

	ME111	AE162
Student enrolment	35	43
# (%) who responded to the survey	22 (63%)	28 (65%)
Response: *Very helpful*	8 (36%)	13 (46%)
Response: *Helpful* (2 of these respondents attended only one workshop)	11 (50%)	14 (50%)
Response: *Not helpful*	2 (9%)	1 (4%)
Did not attend any workshops.	1 (5%)	1 (4%)
Had difficulty attending due to time conflicts.	3 (14%)	5 (18%)

In ME111 86% of the students found the workshops helpful or very helpful; the percentage was even higher (96%) in AE162. It should be noted that student input was solicited in regards to the times the workshops would be offered, however, considering that more than 2/3 of our students work at least part-time, it was impossible to find times that would accommodate all the students, not to mention conflicts with other courses, in which students were enrolled. Hence, it is suspected that some of the students who did not respond to the survey did not attend the workshops due to time conflicts.

Students indicated that the workshops helped them in the following ways:

- Workshops provided more opportunities for practice in a more relaxed atmosphere.
- Workshops increased their ability for mathematical modelling. As one student said, *I feel that a lot of my previous engineering classes simplify the math until it is algebra or "cookbook" plug-n-chug, and I just forget how to do simple calculus or trigonometry.* This comment provides one explanation why students exhibit such poor mathematical skills despite the fact that have successfully completed three calculus courses and all engineering courses have calculus as a prerequisite.
- Student leaders coached them into developing a problem solving approach.
- They were able to get immediate help, when they needed it.
- Student leaders would not give them answers but rather they provided hints, so they (students) were challenged to think more on their own. In one student's words: *Workshops forced me to work through each problem in ways I wouldn't normally be attempting while studying on my own.*
- Workshops exposed them to different kinds of problems, including open-ended, and forced them to look at problems from different angles.
- The problems selected for the workshops were challenging; this greatly enhanced their problem solving skills.
- Workshops helped them identify weaknesses in their understanding of the material while at the same time gave them opportunities to address these weaknesses.

As one student confessed, *without the workshops, I would not have studied as much as I should for the makeup exams*! This explains our previous finding, namely that one of the reasons students performed poorly on makeup tests in the past, was simply because they did not take the opportunity to improve their scores seriously enough. The student comments together with the statistics presented in Section 5.1 indicate that the workshops may have indeed addressed some of factors that contribute to poor problem solving skills among our students. In particular, they seem to have adjusted student attitudes towards problem solving.

5.3 The Student Leaders' Perspective

A large number of students enter college with the misconception that doing well in a course lies in the ability to repeat verbatim information from the text or the lectures. Ironically, poor study habits are reinforced not only through a student culture developed over time but also through certain faculty practices. For example, many faculty members give exams with problems identical to examples presented in class or in the text hence many students tend to think that the process to solve an engineering problem involves finding and copying the solution from some source. To make things worse, in many courses these students are rewarded with exams that change very little, year after year.

The workshops described here offer peer-to-peer instruction, in a more relaxed learning environment. Often students do not feel comfortable asking questions in class because they worry that their questions may reveal a lack of understanding of basic concepts. Some students even lack the ability to compose their thoughts into reasonable questions. On the other hand, students find it easier to engage with workshop leaders, who are familiar with the course content as well as the teaching style and expectations of the professor. Workshops also help student leaders develop professionally by giving them an opportunity to coach their peers.

6. CONCLUSION

Student-led, active learning workshops were implemented in a variety of engineering courses in an effort to improve student problem solving skills. These workshops were run by members of the aerospace engineering honour society and will become a permanent feature in courses taught by the first author. Clearly, the workshops cannot address all the underlying factors, which contribute to poor test performance, however students received them enthusiastically and the data presented in this paper show improved test scores as a result of these workshops. Student leaders benefit from the workshops in a variety of ways, the most important being development of coaching skills. Following student recommendations, workshops will be offered on a weekly basis to provide students with opportunities to be coached in problem solving on a regular basis, for each and every topic of their coursework. It is hoped that weekly workshops will increase sufficiently the percentage of students who attain the 70% target on the first attempt, eliminating the need for makeup tests.

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